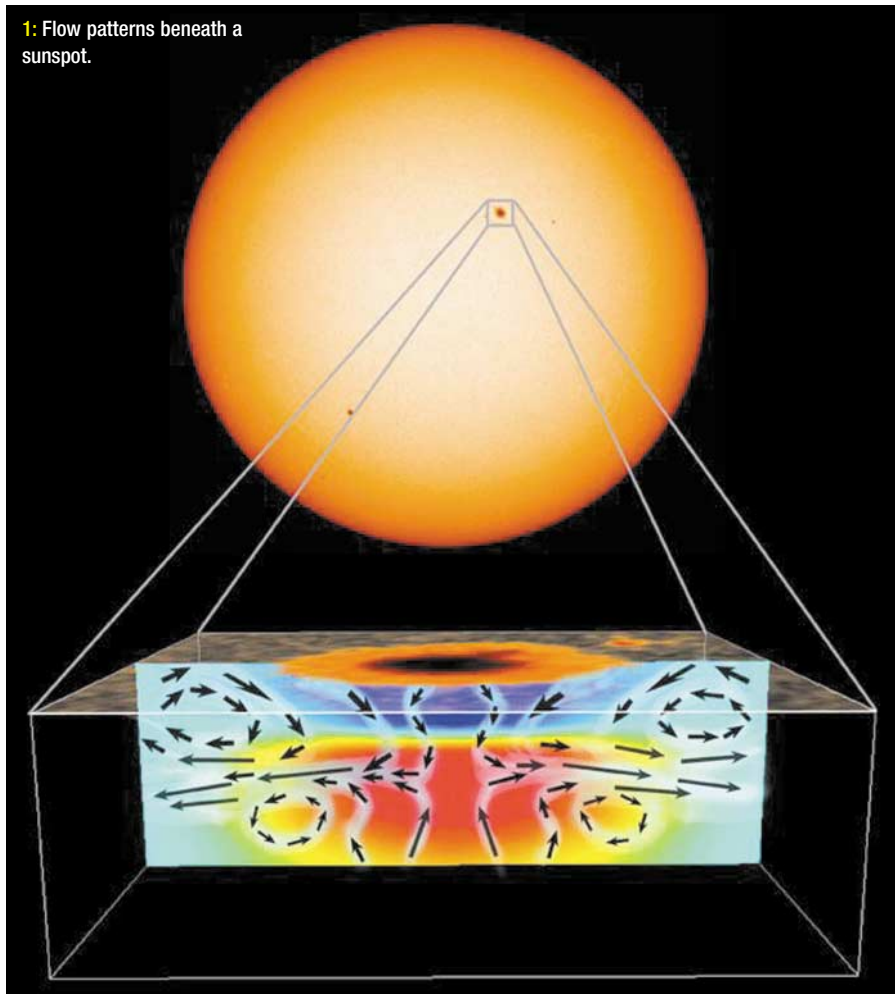


1: Flow patterns beneath a sunspot.



Solar physics in Dublin

This year's Annual UK Solar Physics meeting took place jointly with the NAM in Dublin, Ireland. Just as in the previous two years there was a record turn-out: well over 100 solar physics researchers gathered from all over the UK and abroad. Whether it was the excellent science programme offered or the attractions of Dublin, it is not easy to decide. The presence of colleagues and friends from the USA who participated throughout the meeting was a welcome development.

The meeting kicked off with a short and warm welcome by **Robert Erdélyi** (Chairman, UKSP) followed by the first session on the solar interior, with **Bernie Roberts** (St Andrews) as chair. **Steve Tobias** (Leeds) in his review gave a thoughtful account of recent progress in solar dynamo theory. He outlined the current paradigm for

This year's annual UK Solar Physics meeting took place in Dublin from 7–11 April 2003, overlapping with the National Astronomy Meeting. **R Erdélyi**, **L Fletcher** and **G J Doyle** summarize.

dynamo action at the base of the solar convection zone. The possible locations of the solar α -effect was discussed, plus the role of turbulent transport and the interaction of shear flows with magnetic buoyancy instabilities. **Nigel Weiss** (Cambridge) showed his latest results on flux pumping and penumbral structure in sunspots. Flux pumping by compressible convection is a robust mechanism and he pro-

posed that these field lines are dragged downwards by granular convection outside the spot. This effect also explains the abrupt appearance of a penumbra as a pore increasing in size. **Joanne Mason** (Leeds) revealed some competing α -effects in solar dynamo theory. The solar magnetic field is generated by the action of a hydrodynamic dynamo, in which both the poloidal and toroidal components of the field are continually regenerated. Although there is a consensus that the toroidal field is generated at the base of the convection zone, the site for the reverse process remains open to debate. Her results demonstrated that the interface dynamo is considerably more effective than the surface dynamo, even if the interface generation mechanism is substantially weaker. The session was closed by another Leeds talk, **David Hughes** on the instability of the magnetic field in the solar tachocline. It is strongly believed that the Sun's toroidal magnetic field is generated in this thin region of strong radial variation in angular velocity just beneath the convection zone. From here the magnetic field escapes, because of magnetic buoyancy instability, eventually to appear at the surface as, for example, active regions. David discussed the nature of the onset of magnetic buoyancy instability with shear flow. Using the energy principle he also derived a new criteria for instability, complemented by a numerical solution of the unstable modes and went on to derive general points regarding the interaction between magnetic buoyancy instability and shear flow, and their relevance to the tachocline field.

Photosphere and chromosphere

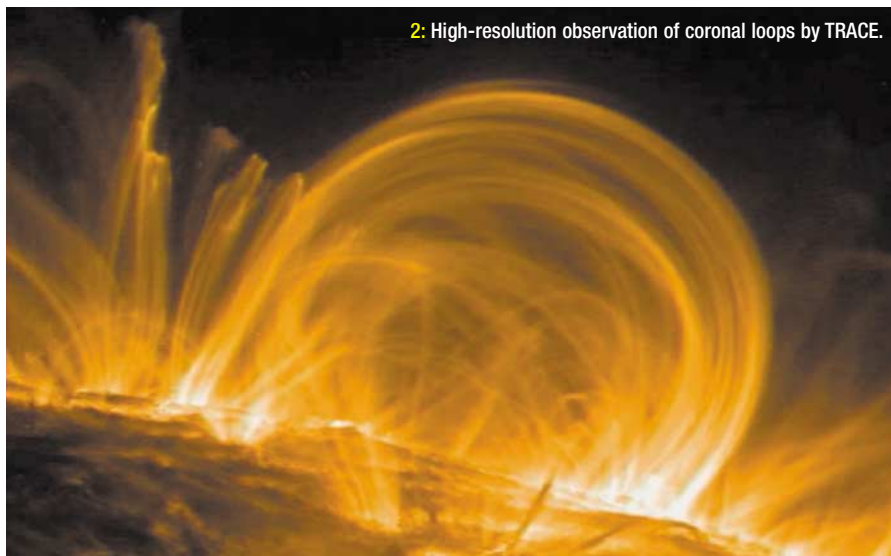
After lunch we continued with the photosphere and chromosphere, chaired by **Nigel Weiss**. The first talk was an invited review given by **John Leibacher** (National Solar Observatory, USA) who was welcome, in particular, because he is also the President of the Solar Physics Division (SPD) of the AAS. There is already excellent collaboration between UK and US solar-physics researchers and with this formal invitation the organizers of UKSP wished to strengthen our links. In his talk John reviewed current developments in helioseismology, including the basic observational phenomena themselves and their description, major ground and space-based observational programmes underway, methods by which inferences of the underlying properties may be obtained, a sampler of the latest results about the time-varying solar interior, and the promise and challenges for the future from axions, dynamos, subsurface "weather" and asteroseismology.

Next, **Robert Close** (St Andrews) investigated the magnetic carpet. The photosphere of the quiet Sun consists of numerous magnetic flux fragments of both polarities that evolve with granular and supergranular flows called the magnetic carpet. These concentrations give rise

to a web of intermingled magnetic flux tubes which characterize the coronal magnetic fields. **Balazs Pintér** (Sheffield) discussed the latest BiSON (Birmingham Solar Oscillation Network) results. The solar mean magnetic field (SMMF), i.e. the line-of-sight magnetic field of the Sun as a star, has been measured by the BiSON instrument at Sutherland (South America) since 1992. The major principles of the measurement method and data reduction were presented. **Valentina Zharkova** (Bradford) talked about a technique developed for automated identification of sunspot in Ca K1 and white-light SOHO/MDI images and the corresponding magnetic field configuration and fluxes observed. Full-disk high-resolution solar images were preprocessed, then the region growing, local contrast and contiguity techniques were used to extract the area, shape, umbra/penumbral location of the detected sunspots and their basic classification. These sunspot identification results were compared with the magnetograms obtained for a corresponding time showing a correlation between the identified sunspot areas and observed magnetic fluxes. The last talk in this session was given by **Therese Kucera** (Goddard, USA) on prominence motions observed at high cadences in temperatures from 20 000 to 250 000 K. UV movies of prominences revealed common multi-thermal features with speeds of $5\text{--}70\text{ km s}^{-1}$ – noticeably higher than the typical speeds of $5\text{--}20\text{ km s}^{-1}$ found in H α data from quiet prominences and more typical of active prominences. Data obtained from SOHO/CDS's wide slit provided fantastic movies taken with cadence >1 image per minute simultaneously in He I, O V, and Mg IX lines. In many cases the motions were the same over temperature ranges from 20 000 to 250 000 K.

Transition region dynamics

After coffee we moved on to transition region dynamics, chaired by **Barbara Bromage** (UCLan). **Maria Madjarska** (Armagh Observatory) summarized significant developments in the field of solar transition region physics, largely thanks to successful space missions allowing more precise models. She focused on the most common small-scale dynamic phenomena in the transition region: explosive events, blinkers, transient brightenings, spicules and bright points as seen in the EUV with SOHO and TRACE. **Steve Bradshaw** (Cambridge) argued for the importance of non-equilibrium radiation in solar loop models, using a series of hydrodynamic simulations of a cooling coronal loop. Significant deviations from equilibrium were found for the populations of several strongly emitting transition-region ions, including those of carbon, oxygen and magnesium, leading to significant deviations of the total plasma emissivity from its equilibrium values.



2: High-resolution observation of coronal loops by TRACE.

James McAteer (QUB) moved on to oscillations of the quiet Sun, based on four TRACE wavebands (1216, 1550, 1600, 1700). Innovative use of wavelet analysis – allowing automated wavelet analysis of almost one million light-curves – helped to discover the distribution of frequencies and durations of significant oscillatory motions. Initial results showed a distinction between network and internetwork regions, with improved statistical significance over previous Fourier analysis. These results await a theoretical explanation. Next **Carole Jordan** (Oxford) discussed transient events in lines of Ne V, VI and VII. She reported an unusual transient brightening in a network boundary region observed with CDS. The event is most pronounced in the Ne VI 562.8 Å line, but is also apparent in the Ne V 572.3 Å and Ne VII 571.7 Å lines. The event is most significant in the narrow temperature range of 3×10^5 to 5×10^5 K, and lasted for at least 53 min, over an area of 220 arcsec². The electron density is not unusually high. She suggested the event is not a blinker, but represents the injection of new mass into a pre-existing loop structure or the emergence of a new loop. Finally, **Clare Parnell** (St Andrews) closed the session with her contribution on magnetic reconnection and flux evolution of interacting photospheric fragments. Reconnection driven by the interaction of opposite-polarity sources is likely to be a key coronal-heating mechanism. A potentially more lucrative energy source, however, comes from the passing of opposite-polarity sources. Three-dimensional MHD experiments were used to investigate. Early results suggested that separator reconnection is much faster and more efficient than fan reconnection.

Although there were no UKSP sessions on Tuesday morning, there was no time to relax. The NAM Plenary Session included an interesting and stimulating talk by **Judith Lean** (NRL, USA) on the relations between the Sun and Earth's climate, highlighting many solved

and still unsolved subtleties of the solar-terrestrial system, and an overview of ESA's Vision 2020 Programme presented by **David Southwood** (Director of Science, ESA).

Coronal heating

On Tuesday afternoon, we continued with a session on coronal heating chaired by **Robert Erdelyi** (Sheffield). First, **Rekha Jain** (UMIST) described her work on two-dimensional forced magnetic reconnection, investigating these processes for a resistive, compressible plasma with the object of studying the effect of forced magnetic reconnection on plasma heating. **Istvan Ballai** (also Sheffield) then reviewed theoretical models suggested to resolve the coronal heating problem discussing, in particular, the constraints on proposed heating theories derived from high-resolution space and ground-based observations. In spite of research spanning more than half a century, this key problem in space physics remains unresolved. But recent satellite missions (Yohkoh, SOHO, TRACE and RHESSI) supported by joint ground-based observations may bring the answer closer. Next, **Philippa Browning** (UMIST) investigated a model that predicts coronal heating by a series of discrete events of various energies, analogous to the range of events observed. She proposed that an energy-release event occurs when a field becomes linearly unstable to ideal MHD modes, with dissipation during the nonlinear phase of such an instability due to reconnection in fine-scale structures such as current sheets. This was followed by **David Pontin** (St Andrews) on the nature of an even more complex 3-D magnetic reconnection. He explained how 3-D reconnection in a finite diffusion region is different in many aspects from 2-D reconnection at an X-point. In 2-D, two flux tubes break at a single point and rejoin to form two new flux tubes. In 3-D, the magnetic field lines continually change their connections throughout the diffusion region rather than just at one point. The

More solar physics sessions in Dublin

The SOHO Coronal Diagnostic Spectrometer (CDS) Users Group Meeting took place on Friday as part of the NAM, with around 40 regular users of the CDS instrument from around the world in attendance. A technical session with presentations by **Andrzej Fludra** (GSFC/RAL), **Carl Foley** (MSSL), **Steven Chapman** (UCLan) and **Peter Young** (RAL), was followed by science discussions on active region science (**Peter Young**, **Giulio Del Zanna**, **Helen Mason**, **Olav Kjeldseth-Moe**

[U. Oslo]) and the analysis of large CDS data sets (**Olav Kjeldseth-Moe**, **Barbara Bromage** [UCLan]). Additional science presentations were given by **Ignacio Ugarte Urrea** (Armagh Observatory), **Raju Kuttickat** (UCLan), **Terje Fredvik** (U. Oslo) and **Peter Gallagher** (NASA Goddard Space Flight Center). As with all good meetings, this ended by pointing the way to the future, as **Simon Martin** (RAL) discussed the UK's part in the European Grid of Solar Observatories.

session was closed by a lively talk given by **Robert Walsh** (UCLan) on coronal-loop modelling, in which he argued that magnetic loops are the fundamental building blocks of the solar atmosphere. He showed how these structures are heated by observing the thermal profile along such structures and then deducing, from a one-dimensional hydrostatic model, the localized energy input. The advantages and disadvantages of such an approach were discussed, particularly in the light of calculating the temperature from TRACE and SOHO/CDS. The implications of a dynamic component to the energy input were outlined as well as what we can expect from SolarB/EIS observing such features.

After Tuesday afternoon's break we continued with space weather, chaired by **Peter Cargill** (IC). First, **Richard Horne** (BAS) gave an excellent introduction to the fundamentals of space-weather science and its applications. He reviewed the observations that link radiation-belt dynamics to solar-wind drivers and showed why there must be substantial acceleration within the magnetosphere. He also reviewed the most important electron acceleration and loss mechanisms. Applying this knowledge established that satellite anomalies are directly related to geomagnetic storms, and he presented an interesting example of risk prediction provided by BAS to insurance companies. This was followed by **Robert Meier** (NRL, USA) on global imaging of near-Earth space weather. Remote sensing of the space environment near Earth is crucial for securing the global perspective needed to interpret and forecast numerous space-weather phenomena and their societal impacts. Unlike broadband imaging of tropospheric weather, space-weather monitoring can be carried out with spectroscopic imagers operating in the far-ultraviolet spectral region. From his entertaining overview of geospace weather effects, several new remote-sensing approaches, and examples of recent space-weather images from the NASA TIMED and IMAGE missions, many of us learned a lot. **Hilary Kay** (MSSL) then discussed the relationship between solar flares and CMEs by examining the properties of eruptive and non-eruptive flares. While many

high-intensity or long-duration flares are often accompanied by CMEs, so are some smaller or shorter duration flares. Additionally the relative timing of the onset of these events is ambiguous. The characteristics of flares both with and without associated CMEs show the effect of mass ejection on the soft X-ray properties of the flares. She also looked for evidence of the trigger for flares and CMEs, by investigating the non-thermal broadening of soft X-ray emission lines often seen at the onset of flares. Last but not least, **Peter Cargill** (IC) gave an excellent talk on factors influencing the 1 AU transit time of coronal mass ejections. Forecasting the arrival of an ICME at the Earth is the first step towards advanced prediction of geomagnetic storm onset. He compared three existing models of ICME transit to coronagraph and *in situ* observations: all three models performed with a similar level of accuracy (i.e. an average error between observed and predicted 1 AU transit times of approximately 11 hours). He reported on factors influencing CME transit that must be understood in order to improve long-term space-weather prediction.

Coronal structure and dynamics

The Wednesday sessions moved on to consider the outer corona of the Sun with a session on "Coronal structure and dynamics". We began with a review of the theory of waves and oscillations in the corona by **Bernie Roberts** (St Andrews). This theory underpins 'coronal seismology' – an emerging technique whereby the physical properties of the solar corona, particularly in active regions, can be diagnosed by studying the propagation of waves through coronal loops. **Damien King** (Warwick) then described a wavelet analysis of a damped magneto-acoustic wave observed in sunspot plumes by the TRACE satellite. Apart from active regions, the features possibly most obvious in the solar corona viewed at extreme UV or soft X-ray wavelengths are coronal holes, regions of magnetic field that do not close locally at the Sun but somewhere out in interplanetary space. **Steven Chapman** (UCLan) discussed an automated technique for studying the variation of the area in this and

hence the "open" flux over the solar cycle. Long-lived quiescent filaments are often found close to the boundaries of coronal holes, and **Duncan MacKay** (St Andrews) discussed numerical experiments to model the interaction of emerging magnetic flux with the surrounding corona. These models suggest that the filament twist during the rising part of the cycle can be explained by the emergence of tilted bipolar regions and their interaction with overlying, stressed magnetic field. The last talk of the session, by **Giulio del Zanna** (Cambridge), described careful analysis of filter and spectroscopic methods of obtaining the coronal temperature structure in solar active regions, and was an example to all of us of the great care needed in correctly interpreting the wealth of data available.

The final oral session of the UKSP discussed all aspects of solar activity. A review of the production of fast particles in solar flares, and their relationship to the magnetic restructuring of the solar corona was given by **Lyndsay Fletcher** (Glasgow). **Sarah Matthews** (MSSL/UCL) discussed the pre-flare situation, emphasizing that our understanding of the lead-up to these violent explosions is ill-understood, contrasting two events that showed rather different pre-flare behaviour. **David Hughes** (Imperial College London) presented a type of "sandpile" model for solar flares, in which the relaxation of two loops following an initial reconnection event allows each to interact further with surrounding structures in a reconnecting "cascade". Discussing recent observations from the RHESSI satellite, **Alec MacKinnon** (Glasgow) focused on one of RHESSI's observational triumphs, the well-resolved gamma-ray spectral lines which are strong enough to perform γ -ray imaging. He described the limits that can be placed on proton and α -particle energy budgets from these observations. The final talk in the session, by **Richard Fallows** (Aberystwyth), dealt with interplanetary scintillation measurements, used to measure the spectrum of turbulence in the solar wind and its variation with distance. He presented observational evidence that the intrinsic structure of the imaged radio source can influence the measured solar-wind properties.

We wish to thank all authors for their excellent oral and poster contributions. The Dublin UKSP meeting was well-attended throughout, with as many people crammed into the meeting room at the end as at the beginning of the meeting. The quality of our work and people was praised by Prof. John Leibacher (National Solar Observatory, USA) in the most recent edition of the *AAS Solar Physics Division Newsletter*. The next UKSP meeting will be in Edinburgh from 29 March to 1 April 2004. ●

R Erdélyi, University of Sheffield; L Fletcher, University of Glasgow; G J Doyle, Armagh Observatory.